FORM PTO-1390 (REV. 9-2001) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER: 7442-2

U.S. APPLICATION NO. (If known, see 37 CFR 1.5): 10/031050

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB00/02057	May 26, 2000	May 28, 1999

TITLE OF INVENTION: MIXING MACHINES

APPLICANT(S) FOR DO/EO/US: Jonathan Bridge Fletcher and Peter R. Wood

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   a. ☐ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☒ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☒ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:

International Preliminary Examination Report

"Express Mail" label number EL683236799US Date of Deposit Jan 15, 2002 I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR § 1.10 on the date indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Gail Mercer

531 Rec'd PCT/PTO 15 JAN 2002

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
10/031050	PCT/GB00/02057	7442-2

21. ☒ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1040.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$890.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$740.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	16 - 20 =	0	x **$18.00**	$
Independent claims	3 - 3 =	0	x **$84.00**	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$280.00**	$
TOTAL OF ABOVE CALCULATIONS =				$ 890.00
☒ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.			+	$
SUBTOTAL =				$ 445.00
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				$
TOTAL NATIONAL FEE =				$ 445.00
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$
TOTAL FEES ENCLOSED =				$ 445.00
			Amount to be refunded:	$
			charged:	$

a. ☒ A check in the amount of $ 445.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No 23-3030. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

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NAME

28,309
REGISTRATION NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re patent application of:	)	Express Mail No. EL683236799US
	)	
Jonathan Bridge Fletcher et al.	)	January 15, 2002
	)	
Serial No. (unknown)	)	
	)	
Filed Herewith	)	
	)	
MIXING MACHINES	)	
	)	
US National Stage of PCT/GB00/02057 International Filing Date May 28, 1999	)	

PRELIMINARY AMENDMENT

Hon. Assistant Commissioner of Patents

Washington, D.C. 20231

Sir:

Please enter the following Preliminary Amendment in the above-identified patent application. The Commissioner is hereby authorized to charge payment of any additional fees associated with this application or credit any overpayment to Deposit Account No. 23-3030.

IN THE CLAIMS

Please cancel claim 17.

Please amend the claims as follows:

Version with Markings to Show Changes Made

CLAIMS

1. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having an axially extending projection and being rotatable so as to present a leading face of the projection to the material being mixed, wherein the leading face has a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.

2. A mixing machine according to claim 1, wherein each projection has a tip that defines a surface facing a substantially complementary wall of the mixing chamber, there being a clearance between the surface and the wall.

3. A mixing machine according to claim 2, wherein both rotors have such a projection and the loci defined by the periphery of the rotors during rotation intersect one another.

4. A mixing machine according to claim 2 ~~or 3~~, wherein the surface of the tip of the first portion increases in circumferential length in the axial direction of the rotor.

5. A mixing machine according to claim 4, wherein the ratio of the circumferential lengths at each end of the first portion is in the range 1.1 to 10.

6. A mixing machine according to claim 4, where ratio of the circumferential lengths at each end of the first portion is in the range 1.5 to 3.

7. A mixing machine according to ~~any one of~~ claims 2 ~~to 6~~, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.1 to 0.9.

8. A mixing machine according to ~~any one of~~ claims 2 ~~to 6~~, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.6 to 0.8.

9. A mixing machine according to ~~any one of~~ claims 2 ~~to 8~~, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 50% of the maximum circumferential length of the tip of the first portion.

10. A mixing machine according to ~~any one of~~ claims 2 ~~to 8~~, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 15% of the maximum circumferential length of the tip of the first portion.

11. A mixing machine according to ~~any preceding~~ claim 1, wherein the height of the second portion of the projection above the rotor is lower than or equal to the height of the first portion of the projection.

12. A mixing machine according to claim 11, wherein the height of the second portion is between 25% and 100% of the height of the first portion.

13. A mixing machine according to claim 11, wherein the height of the second portion is between 70% to 90% of the height of the first portion.

14. A mixing machine according to ~~any one of~~ claims 2 ~~to 13~~, wherein the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

15. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases along the axial direction.

16. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface that forms at least 5% of the circumference of the rotor and is tapered so that the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

~~17. A mixing machine substantially as hereinbefore described with reference to the accompanying drawings.~~

Clean copy of Claims

CLAIMS

1. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having an axially extending projection and being rotatable so as to present a leading face of the projection to the material being mixed, wherein the leading face has a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.

2 A mixing machine according to claim 1, wherein each projection has a tip that defines a surface facing a substantially complementary wall of the mixing chamber, there being a clearance between the surface and the wall.

3. A mixing machine according to claim 2, wherein both rotors have such a projection and the loci defined by the periphery of the rotors during rotation intersect one another.

4. A mixing machine according to claim 2, wherein the surface of the tip of the first portion increases in circumferential length in the axial direction of the rotor.

5. A mixing machine according to claim 4, wherein the ratio of the circumferential lengths at each end of the first portion is in the range 1.1 to 10.

6. A mixing machine according to claim 4, where ratio of the circumferential lengths at each end of the first portion is in the range 1.5 to 3.

7. A mixing machine according to claim 2, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.1 to 0.9.

8. A mixing machine according to claim 2, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.6 to 0.8.

9. A mixing machine according to claim 2, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 50% of the maximum circumferential length of the tip of the first portion.

10. A mixing machine according to claim 2, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 15% of the maximum circumferential length of the tip of the first portion.

11. A mixing machine according to claim 1, wherein the height of the second portion of the projection above the rotor is lower than or equal to the height of the first portion of the projection.

12. A mixing machine according to claim 11, wherein the height of the second portion is between 25% and 100% of the height of the first portion.

13. A mixing machine according to claim 11, wherein the height of the second portion is between 70% to 90% of the height of the first portion.

14. A mixing machine according to claim 2, wherein the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

15. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases along the axial direction.

16. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface that forms at least 5% of the circumference of the rotor and is tapered so that the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

[redacted]

REMARKS

Consideration and allowance of the above-identified patent application is requested.

Respectfully submitted,

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MIXING MACHINES

The present invention relates to mixing machines of the kind that are used to mix batches of polymeric compound.

Mixing machines of the kind defined above are typically heavy duty machines used in the mixing of rubber, plastics or other viscoelastic materials exhibiting high viscosity during mixing that may need to be mixed with fillers, oils, colorants and chemical modifiers.

Such mixers comprise two counter-rotating rotors disposed in parallel in a mixing chamber. A pneumatic or hydraulic ram or pusher, the bottom face of which generally forms a top wall of the mixing chamber, forces the material to be mixed towards the mixing chamber and the rotors. The material in the chamber is subjected by contact with the rotors and/or the chamber wall, to a distributive action and to a milling or shearing action which commonly generates heat. The mixed compound is removed from the mixing chamber via a discharge door that is disposed at the bottom of the chamber.

Most mixing machines of this type are based on one of two basic designs. The first and most common is the tangential rotor mixer which was first disclosed in US patent no. 1200070 of October 1916. In such a mixer the rotors are designed to be non-intermeshing so that the loci described by the peripheries of the rotors do not intersect. The compound material to be mixed is compressed and sheared against the internal face of the wall of the mixing chamber in the early part of the mixing cycle whilst the temperature of the compound is still low. This action breaks down and disperses the raw ingredients of the mix but as the temperature increases later in the cycle the viscosity of the mix decreases resulting in less shear and dispersive action but more distributive action. In most machines of this type the rotors are non-synchronous and have a helical profile.

The second type of design is the intermeshing rotor mixer that was disclosed in US patent No. 2015618 dated 1935. In such mixers the loci described by the peripheries of the rotors during rotation intersect. The rotors generally have outwardly extending projections (such as wings or nogs) and rotate synchronously to ensure that

there is no contact between projections on the respective rotors. The projections are generally of a helical configuration and are designed to ensure good distribution of the materials to be mixed early in the mixing cycle. As the temperature increases and the viscosity decreases the mix starts to flow across the projections and dispersion of the materials is effected.

The benefits of each type of mixing machine are well recognised and understood by those skilled in the field. Since there are different phases in a mixing cycle the design of any mixing machine is always a compromise of features to ensure that the discharged mix is of an acceptable standard. Attempts have been made to combine the advantages of each of the two machine types, generally by incorporating features of the tangential machine into the intermeshing type. Such designs have often included the reduction of the leading angle of the helical wing of the intermeshing rotor to force material to flow over the wing earlier in the mixing cycle and to attempt to incorporate the compression or rolling action of the tangential rotor machine into the intermeshing rotor machine.

It is an object of the present invention to mitigate the aforesaid disadvantages of existing mixing technology and to provide for an improved mixing machine.

According to a first aspect of the present invention there is provided a mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends along at least a part of the axial length of the rotor and the rotors being rotatable so as to present a leading face of the projection to the material being mixed, wherein the leading face has a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.

The invention thus exploits the advantages of both conventional tangential (in which the leading face of a wing is convex) and intermeshing (in which the leading face of a wing is concave) rotors.

Each projection may have a tip that defines a surface facing a substantially complementary wall of the mixing chamber, there being a clearance between the surface and the wall.

Preferably both rotors have such a projection and the loci defined by the periphery of the rotors during rotation intersect one another.

The ratio of the axial length of the first portion to the total length of the rotor may be anywhere in the range 0.1 to 0.9 but is preferably 0.6 to 0.8.

The surface of the tip of the first portion preferably increases in circumferential length in the axial direction of the rotor. The ratio of the circumferential length at each end of the first portion may be in the range 1.1 to 10 but is preferably 1.5 to 3.

The circumferential length of the tip of the second portion of the projection is preferably consistent in the axial direction of the rotor and may be between 3% and 50% of the maximum circumferential length of the tip of the first portion but is preferably between 3% and 15%.

The height of the second portion of the projection above the rotor may be lower than or equal to the height of the first portion of the projection. The height of the second portion may be between 25% and 100% of the height of the first portion but is preferably in the range 70% to 90%.

The clearance defined between tip surface and the mixing chamber wall may decrease in the direction of rotation of the rotor by virtue, for example, of the surface being tapered.

According to a second aspect of the present invention there is provided a mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases in the axial direction of the rotor.

According to a third aspect of the present invention there is provided a mixing machine comprising a mixing chamber in which there are disposed at least two rotors

arranged for rotation in opposite directions about respective rotational axes, wherein at least one of the rotors has a projection that extends axially along the rotor, the projection having a tip defining a circumferential surface that forms at least 5% of the circumference of the rotor and is tapered so that the clearance defined between the tip surface and a wall of the mixing chamber decreases in the direction of rotation of the rotor.

A specific embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic representation of a section through a mixing chamber of a mixing machine of the present invention;

Figure 2 is a plan view of the unwrapped envelope of a rotor of the mixing machine of figure 1;

Figure 3 is an end view of the rotor in the direction of arrow X of figure 2;

Figure 4 is an end view of the rotor in the direction of arrow Y of figure 2; and

Figure 5 is a cross section through a leading face of a main wing of the rotor of figure 2.

Referring now to the drawings, the exemplary mixing machine is a high-powered, heavy duty machine that is intended for the mixing of rubber and polymeric compounds. The machine has a housing 1 having an internal wall 1a that defines a mixing chamber 2 in which two parallel contra-rotating rotors 3, 4 are disposed. A hydraulically or pneumatically operated ram 5 closes the chamber 2 and, in use, serves to force material towards the rotors 3, 4.

Each rotor 3, 4 is generally cylindrical and has a plurality of helical wings 6, 7, 8 that project radially outward towards the wall 1a of the mixing chamber 2. The wings 6, 7, 8 of one rotor 3, 4 are arranged in such a way that they project into spaces 9 defined between the wings 6, 7, 8 of the adjacent rotor 3, 4 and are disposed such that the loci described by the periphery of the wings 6, 7, 8 of one rotor 3, 4 intersect that of the other during rotation. At the nip defined between the intermeshing surfaces of the two rotors 3, 4 and between the surfaces of each rotor 3, 4 and the chamber wall 1a there is a small clearance 10 through which materials may pass during mixing.

The wings 6, 7, 8 have profiles that have been carefully designed to provide for zones that act on the mix in different ways. A main wing 7 extends helically from a first end of each rotor 3, 4 to the other end and has a discontinuity 11 dividing its profile into first and second axial portions 12, 13. The first portion 12 has an axial length indicated by l_2 and a tip 14 that, after a lead-in formation 15, increases in circumferential length from dimension w_1 to dimension w_2. The second portion 13 has an axial length indicated by l_1 and a tip 16 with constant circumferential length indicated by w_3.

The first portion 12 of the main wing 7 has a leading face 17 whose shape is consistent along its axial length. In cross-section a predominant portion of the leading face 17 extending between the base of the wing 7 and a position near the edge 18 defined at the intersection of the leading face 17 and the tip 14, is concave (represented by 17a in figure 5) with the remainder being planar (indicated by 17b in figure 5) and extending substantially in a radial direction. In contrast, the leading face 19 of the second portion 13 of the main wing 7 has a convex profile. Thus the configuration of the first portion 12 of the wing 7 resembles that of an intermeshing mixer, whereas the profile of the second portion 13 resembles that of a tangential rotor.

The relationship between the dimensions for a particular pair of rotors may be dependent on the particular compound that is to be mixed. The ratio $\frac{l_r}{l_1+l_2}$ could have a value of anywhere in the range 0.1 to 0.9 but it is more likely to fall in the range 0.6 to 0.8. Similarly the ratio $\frac{w_2}{w_1}$ may be in the range 1.1 to 10 but is preferably in the range 1.5 to 3. The ratio of the circumferential length of the second portion 13 of the main wing 7 to that of the adjacent first portion, i.e. $\frac{w_3}{w_2}$, will vary depending on the compound to be mixed but may be in the range 0.03 to 0.5 with a preferred figure of between 0.03 and 0.15.

The dimension w_1 of the wing tip is at least 5% of the circumference of the rotor.

The height h of the second portion of the main wing 7 may be anywhere in the range 25% to 100% of the height of the first portion 12 of the main wing 7 although a preferred figure is likely to be in the range 70% to 90% of that height.

In certain embodiments of the machine the surface of the wing tip 14 of the first portion 12 may be tapered so that the clearance between the tip 14 and the chamber wall 1a decreases in the direction of rotation of the rotor 3,4. The angle of incline of the taper is relatively small subtending an angle of between 1 second and 10 degrees to a conventional rotor concentric surface. The taper is indicated by the change in height t in figure 3.

In use, material to be mixed is introduced into a hopper (not shown) whilst the ram 5 is raised so as to permit the materials to pass into the mixing chamber 2. The ram 5 is then operated to move the material towards the rotors 3,4. After the material has been mixed by the rotors and dispersed it is discharged from an outlet door (not shown) at the bottom of the mixing chamber 2.

At the beginning of the mixing cycle the material is drawn into the nip between the rotors 3,4 and the leading face 17 of the first portion 12 of the main wing 7 ensures rapid ingestion. Initially, the ingested material is relatively hard and flows along the concave leading face 17 of the first portion 12 of the main wing 7 until it encounters the convex leading face 18 of the second portion 13. At this point the material is worked between the second portion 13 of the wing 7 and the wall 1a of the mixing chamber 2 where it encounters a rolling and compressive action which provides a more rapid increase in temperature and reduction in viscosity of the material than occurs along the first portion 12. This temperature increase and viscosity reduction enables the material to flow more easily across the tip 14 of the first portion 12 of the main wing 7 where it is worked between the rotors 3,4 and between the rotors 3, 4 and the wall 1a of the mixing chamber 1 where it is subjected to significant dispersion and shear stress. Material is still caused to flow axially along the concave leading face 17 of the first portion 12 of the main wing 7 and will be subject to some temperature increase and viscosity reduction as it flows along this face. That material which flows over the tip of the wing 7 will move

circumferentially across tip 14 (and tip 16) of wing 7. To maintain constant shear and flow across tip 14 of the first portion 12 of the main wing 7 with this reducing material viscosity, the circumferential width increases from w_1 at the end of the rotor 3, 4 to w_2 at the end adjacent to the discontinuity.

The profile of the second portion 13 of the wing 7 is akin to that of a tangential rotor and serves to provide a rapid increase in temperature of the material so that it is able to flow over the wing tip 14 surface of the first portion 17 much earlier in the mixing cycle.

The taper t on wing tip surface 14 presents a constant compression and shear force to the material in a circumferential direction as the increase in temperature and reduction in viscosity occurs in the material as it passes across face 14 of the first portion 12 of the main projection 7. Without this taper, the reduction in viscosity caused by temperature generated in the material would result in a reducing shear on the material as it passes across the projection.

The subordinate wings 6 and 8 are provided to direct material away from the ends of the chamber and back into the main mixing flow so as to prevent material from apply pressure to dust covers and bearings located at the rotor ends. In existing machines it has been known for material to egress from the machine at these points. The wings 6, 8 also provide a small contribution to the kneading action of the rotor.

By providing rotors with wings having profiles that define separate mixing zones which act on the material to be mixed in different ways the quality and efficiency of the mixing action is improved.

It will be appreciated that numerous modifications to the above described design may be made without departing from the scope of the invention as defined in the appended claims. For example, the leading face of the second portion of the main wing may not be convex along its entire length but may have, for example, a relatively small planar portion. In addition, the taper t is considered a feature that may be used on any form of rotor wing provided the circumferential length of the projection is at least 5% of the rotational circumference of the rotor. Moreover, the

increase in circumferential length of the rotor may be used on rotors that do not have the discontinuity or the tapered wing tip.

CLAIMS

1. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having an axially extending projection and being rotatable so as to present a leading face of the projection to the material being mixed, wherein the leading face has a discontinuity in its profile along the axial direction of the rotor so as to define first and second portions, a majority of the leading face of the first portion being concave and a majority of the leading face of the second portion being convex.

2. A mixing machine according to claim 1, wherein each projection has a tip that defines a surface facing a substantially complementary wall of the mixing chamber, there being a clearance between the surface and the wall.

3. A mixing machine according to claim 2, wherein both rotors have such a projection and the loci defined by the periphery of the rotors during rotation intersect one another.

4. A mixing machine according to claim 2 or 3, wherein the surface of the tip of the first portion increases in circumferential length in the axial direction of the rotor.

5. A mixing machine according to claim 4, wherein the ratio of the circumferential lengths at each end of the first portion is in the range 1.1 to 10.

6. A mixing machine according to claim 4, where ratio of the circumferential lengths at each end of the first portion is in the range 1.5 to 3.

7. A mixing machine according to any one of claims 2 to 6, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.1 to 0.9.

8. A mixing machine according to any one of claims 2 to 6, wherein the ratio of the axial length of the first portion to the total length of the rotor is in the range 0.6 to 0.8.

9. A mixing machine according to any one of claims 2 to 8, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 50% of the maximum circumferential length of the tip of the first portion.

10. A mixing machine according to any one of claims 2 to 8, wherein the circumferential length of the tip of second portion of the projection is consistent in the axial direction of the rotor and is between 3% and 15% of the maximum circumferential length of the tip of the first portion.

11. A mixing machine according to any preceding claim, wherein the height of the second portion of the projection above the rotor is lower than or equal to the height of the first portion of the projection.

12. A mixing machine according to claim 11, wherein the height of the second portion is between 25% and 100% of the height of the first portion.

13. A mixing machine according to claim 11, wherein the height of the second portion is between 70% to 90% of the height of the first portion.

14. A mixing machine according to any one of claims 2 to 13, wherein the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

15. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface whose circumferential length increases along the axial direction.

16. A mixing machine comprising a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes, at least one of the rotors having a projection that extends axially along the rotor and has a tip defining a circumferential surface that forms at least 5% of the circumference of the rotor and is tapered so that the clearance defined between the tip surface and the mixing chamber wall decreases in the direction of rotation of the rotor.

17. A mixing machine substantially as hereinbefore described with reference to the accompanying drawings.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *Without international search report and to be republished upon receipt of that report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

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(54) Title: MIXING MACHINES

(57) Abstract: A mixing machine has a mixing chamber in which there are disposed at least two rotors arranged for rotation in opposite directions about respective rotational axes. The rotors have a helical projection and are rotatable so as to present a leading face of the projection to the material being mixed. The leading face has a discontinuous profile along the axial direction of the rotor so as to define first and second portions. A majority of the leading face of the first portion is concave and a majority of the leading face of the second portion is convex. The circumferential length of a tip surface of the projection increases in the axial length of the rotor. A clearance defined between the tip of the projection and a facing wall of the mixing chamber decreases in size in the direction of rotation of the rotor. The rotor profiles are designed to provide zones which act on a material to be mixed in different ways so as to improve overall mixing quality and efficiency.

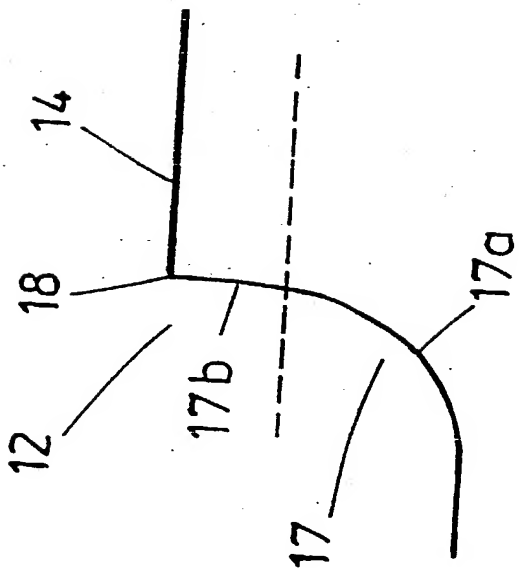

FIG. 5

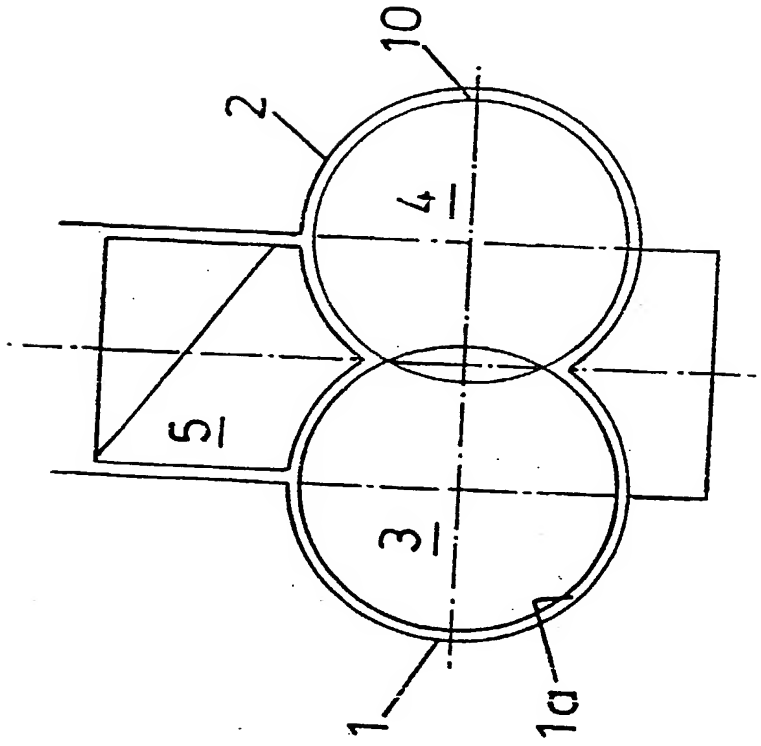

FIG. 1

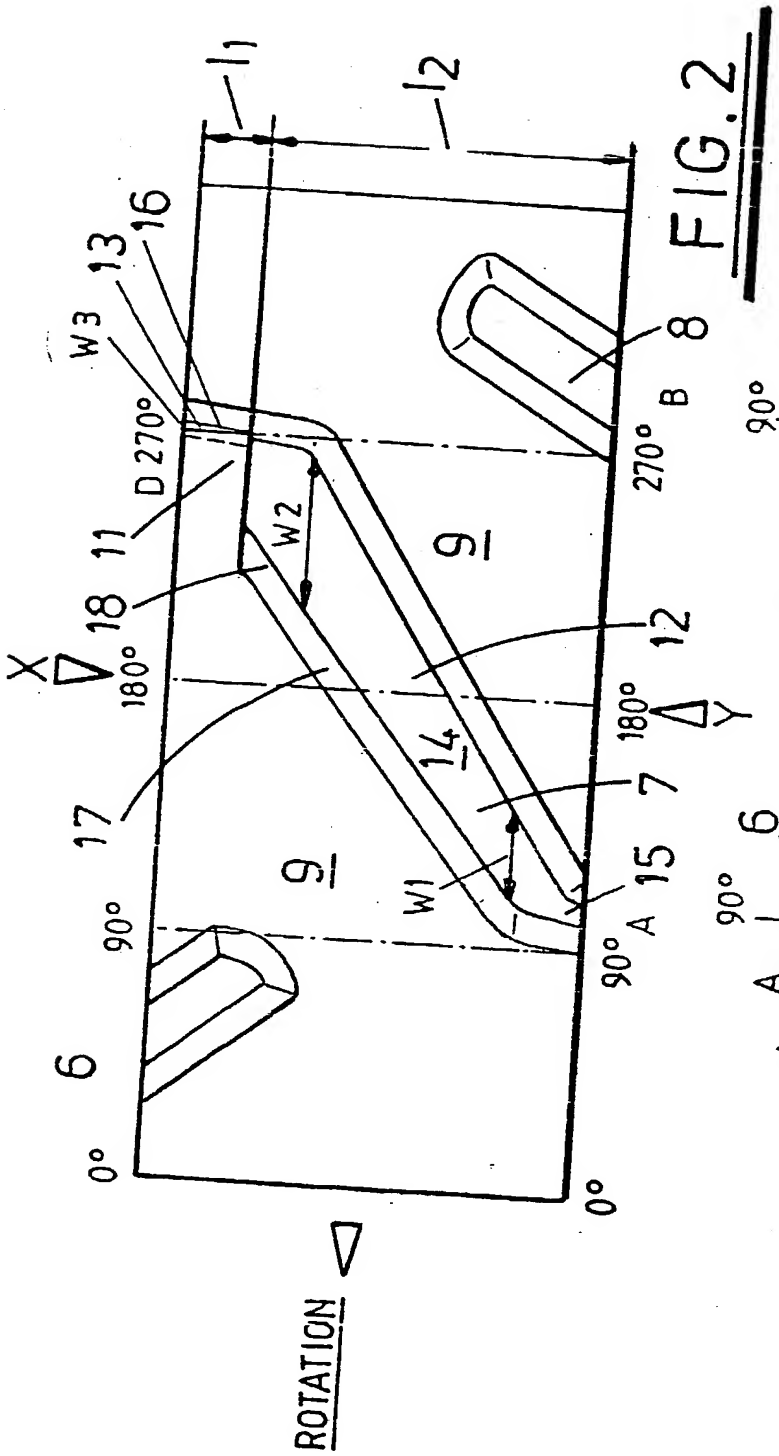

FIG. 2

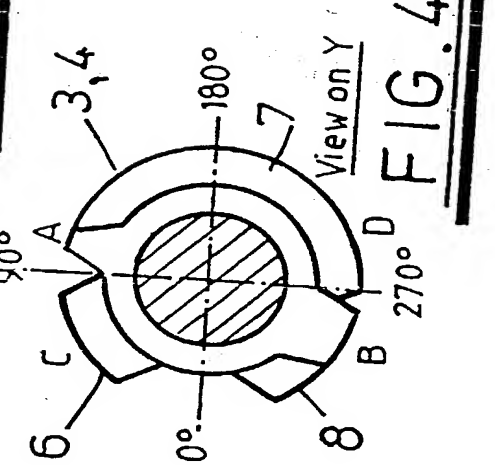

FIG. 4

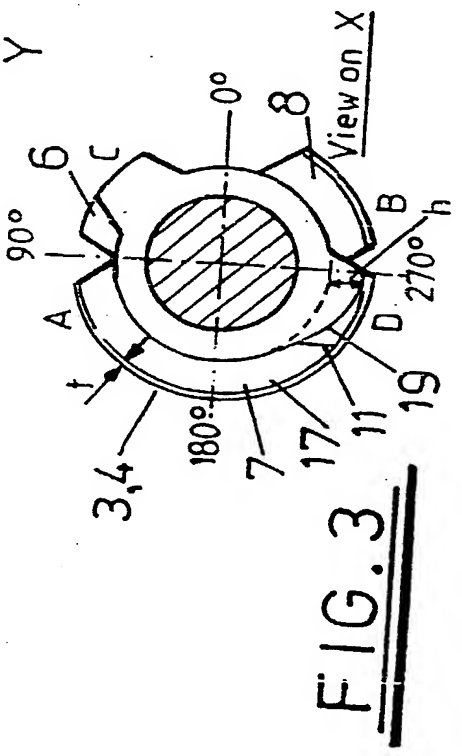

FIG. 3

#6

WENMM SB/01 (2-99)

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Attorney Docket Number	7442-2
First Named Inventor	Jonathan Bridge Fletcher

☐ Declaration submitted with Initial Filing

☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

COMPLETE IF KNOWN

Application No.	10/031,050
Filing Date	
Group Art Unit	
Examiner's Name	

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MIXING MACHINES

the specification of which
(check one)

☐ is attached hereto.

☒ Was filed on May 26, 2000 as United States Application No. or

PCT International Application No. PCT/GB00/02057

☐ And was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YY)	Priority Not Claimed	Certified Copy Attached? Yes	Certified Copy Attached? No
PCT/GB00/02057	PCT	05/28/2000		☐	☒
GB 9912379.6	GB	05/28/1999		☐	☒

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number (if applicable)

☐ Additional US or PCT International application numbers are listed on a supplement priority data sheet PTO/SB/02B attached hereto.

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☐ Customer Number → *Place Customer Number Bar Code Label Here*

OR

☒ Registered practioner(s) name/registration number listed below.

Name	Registration Number	Name	Registration Number
Thomas Q. Henry	28,309		

(37)

☒ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to : ☐ Customer Number Bar Code Label *OR* ☒ Correspondence address below

Name	Thomas Q. Henry				
Firm Name	WOODARD EMHARDT NAUGHTON MORIARTY & McNETT				
Address	111 Monument Circle, Bank One Tower Suite 3700				
Address					
City	Indianapolis	State	IN	ZIP	46204
Country	USA	Telephone	317/ 634-3456	Fax	317-637-7561

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1-00

Full name of sole or first inventor:			
Given Name (first and middle, if any)	Jonathan Bridge	Family Name or Surname	Fletcher
Inventor's Signature:	X JB Fletcher	Date of Signature:	23 Oct 02
Residence: (City, State, Country)	5 Leighton Avenue, Smithy Bridge Littleborough, Lancashire, OL15 0BW, United Kingdom		GBX
Citizenship:	GB		
Post Office Address:	5 Leighton Avenue, Smithy Bridge Littleborough, Lancashire, OL15 0BW, United Kingdom		

Full name of additional joint inventor, if any:

Given Name (first and middle, if any)	Peter R.	Family Name or Surname	Wood
Inventor's Signature:		Date of Signature:	
Residence: (City, State, Country)	Dunluce, Sunnyside, Todmorden, Lancashire, OL 14 7AP, United Kingdom		
Citizenship:	GB		
Post Office Address:	Dunluce, Sunnyside, Todmorden, Lancashire, OL 14 7AP, United Kingdom		

Full name of additional joint inventor, if any:

Given Name (first and middle, if any)		Family Name or Surname	
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Residence: (City, State, Country)			
Citizenship:			
Post Office Address:			

Full name of additional joint inventor, if any:

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Inventor's Signature:		Date of Signature:	
Residence: (City, State, Country)			
Citizenship:			
Post Office Address:			

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WENMM SB/02C (3-97)

DECLARATION	Registered Practitioner Information (Supplemental Sheet)

Name	Registration Number	Name	Registration Number
Harold R. Woodard	16,214		
C. David Emhardt	18,483		
Joseph A. Naughton, Jr.	19,814		
John V. Moriarty	26,207		
John C. McNett	25,533		
Thomas Q. Henry	28,309		
James M. Durlacher	28,840		
Charles R. Reeves	28,750		
Vincent O. Wagner	29,596		
Steve Zlatos	30,123		
Spiro Bereveskos	30,821		
Clifford W. Browning	32,201		
R. Randall Frisk	32,221		
Daniel J. Lueders	32,581		
Kenneth A. Gandy	33,386		
Timothy N. Thomas	35,714		
Kurt N. Jones	37,237		
John H. Allie	39,088		
Holiday W. Banta	40,311		
Troy J. Cole	35,102		
L. Scott Paynter	39,797		
Charles J. Meyer	41,996		
Matthew R. Schantz	40,800		
Gregory B. Coy	40,967		
Lisa A. Hiday	40,036		
John V. Daniluck	40,581		
Christopher A. Brown	41,642		
C. John Brannon	44,557		
Arthur J. Usher IV	41,359		
Douglas A. Collier	43,556		
Brad A. Schepers	45,431		
Scott J. Stevens	29,446		
James B. Myers	42,021		
John M. Bradshaw	46,573		
Charles P. Schmal	45,082		
Edward E. Sowers	36,015		

12/01

#6

WENMM SB/01 (2-99)

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Attorney Docket Number	7442-2
First Named Inventor	Jonathan Bridge Fletcher

☐ Declaration submitted with Initial Filing

☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16(e)) required)

COMPLETE IF KNOWN

Application No.	10/031,050
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Group Art Unit	
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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

MIXING MACHINES

the specification of which
(check one)

☐ is attached hereto.

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Citizenship:	GB		
Post Office Address:	5 Leighton Avenue, Smithy Bridge Littleborough, Lancashire, OL15 0BW, United Kingdom		

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Given Name (first and middle, if any)	Peter R.	Family Name or Surname	Wood
Inventor's Signature:	X [illegible]	Date of Signature:	X 22/10/2002
Residence: (City, State, Country)	Dunluce, Sunnyside, Todmorden, Lancashire, OL 14 7AP, United Kingdom GBX		
Citizenship:	GB		
Post Office Address:	Dunluce, Sunnyside, Todmorden, Lancashire, OL 14 7AP, United Kingdom		

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WENMM SB/02C (3-97)

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12/01